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Theme: Exploiting Information Systems for Organisational Enhancement

INTERNET BASED CONSTRUCTION PROJECT QUALITY MANAGEMENT SYSTEM

Research in progress track

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Abstract

Quality management (QM) systems have been developed and used by many in the construction industry to ensure right things are done and things are done right the first time. However, current quality systems are designed to monitor and control the "production process" of a specific organization, with the QM data being revealed to the accreditation bodies during the auditing process only. As great deal of data is captured during the QM implementation, and much of this data is related to a construction project involving a multitude of stakeholders, there is a potential to convert the project-specific quality data (collected at an organizational level) into useful information for exploitation by other relevant project participants. The development of an Integrative Project-oriented QM (IPQM) system for construction would satisfy the stringent requirements of client satisfaction and continuous improvement as required by ISO9000:2000. In view of the fragmented nature of the construction industry, a tool that could facilitate easy communication of QM data between different participants is inevitable. The development of Internet technologies may open up new ways to ensure QM data is efficiently and securely transmitted. This paper provides a conceptual framework and prototype decision model for such an IPQM system.

Keywords: *Quality Management, Construction Industry, Internet technologies, decision model.*

Introduction

The construction industry is well known for its time/cost overruns and poor performance, and this can be traced back to the errors/mistakes made during the delivery of goods and services (Deming, 1982). One response to this has been for construction organisations to move away from the traditional 'firefighting' approach (Abdul-Rahman, 1996) to more formal Quality Management (QM) systems to plan, monitor and control their production process (CIRIA, 1987; Latham, 1994; Feist *et al*, 2001; Cheng *et al* 2002). This is in line with the latest ISO9000 standard, which also emphasizes customer satisfaction and continual improvement (Murphy, 2002). However, current construction project practice of QM, which focuses on fulfilling predefined procedures (set by the organization itself), is far from perfect and construction industry researchers (e.g. Seymour and Low, 1990; Low, 1993; Abdul-Rahman, 1996; Moatazed-Keivani *et al*, 1999; Serpell, 1999) have

highlighted a number of factors, such as unnecessary bureaucracy, excessive paperwork, lack of integration with other project management activities, stifling of innovation, etc., that inhibits its effectiveness. One effect of adopting QM though is that, in addition to reserving the captured QM data for auditing purpose, some project-specific quality records kept by the contractor are of potential use to the client and design team for monitoring and controlling project/organizational performance. Likewise, QM data held by clients or consultants, e.g. the payment status, may also benefit the contractor through improved cash flow predictions.

In parallel with developments in QM, have been efforts to increase communications between participants. Since construction projects are complex, dynamic and heterogeneous, poor communication can cause major problems. As a recent industry report points out, "*effective communication with the project team and close involvement of the client throughout the project delivery process facilitate smooth project implementation*" (Tang, 2001), as it helps minimize the gaps between client's expectation and project outcome. As is well known, the development of Information Technology (IT) has huge potential to help in this by bringing all stakeholders to work together more effectively and efficiently (e.g., Baldwin *et al*, 1999; Deng *et al*, 2001) and there have been several calls for the construction industry to adopt the Internet technologies to transact information with each other electronically in a seamless manner (e.g., Sloan and Low, 2000).

One possibility, therefore, is to base an integrated QM approach on this technology (Mohamed and Stewart, 2003) as, by integrating the project-specific QM data of various project participants, a win-win situation may be realized. Accordingly, this paper examines the implications of such an Internet based Integrated Project-oriented QM (also called IPQM hereafter) system for construction projects. In doing this, the relevant quality data is first identified. A conceptual framework is then proposed, together with a suitable prototype model.

Potential of Internet Technologies for use in construction projects

According to Kiuchi and Kaihara (1996), the Internet technologies are suitable for the development of an on-line data collection system, as an Internet-based system is a convenient and cost effective tool for gathering, filtering, managing, and sharing data (Doherty, 1998). For construction projects, Internet techniques have been applied for information gathering and manipulation, such as for transfer of project information (Anumba and Duke, 1997; Faraj *et al*, 2000; Mak, 2001), and development of product libraries (Coyne *et al*, 2001), etc. It has been established that collecting and disseminating real-time quality-related data on-line is both feasible and effective.

Internet systems can also be combined with other decision tools to perform assessment and support decision-making tasks. Many Internet-based models have been devised for construction domains, e.g. for investment decisions (Aydogdu and Parikh, 1997), procurement path selection (Molenaar and Songer, 1998), architectural design and performance evaluation (Goedicke and Meyer, 1999), cost control (Abudayyeh *et al*, 2001), field inspection reporting (Rojas and Songer, 1999), dynamic workflow model (Crowe and Kydd, 2001), project management (Deng *et al*, 2001), etc. Internet technologies, therefore, clearly have a high potential to provide a more accurate,

consistent and cost-effective prediction/assessment on quality performance and improvement regimes.

Electronic-based QM (e-Quality) has been widely adopted in the IT industry to ensure quality is built into Internet and e-commerce projects (Hane, 1999; Melymuka, 2001). e-Quality has also been proposed for medical application (Kiuchi and Kaihara, 1996). Other analogous initiatives include converting the printed quality manual into an Internet-based framework (Macmillan, 1996). However, the full potential of e-Quality in construction especially on setting up an IPQM environment is yet to be realised.

Project-Oriented Quality Information

It is necessary for an Internet-based QM system for construction projects to be operated at two levels: (i) project (micro) level, and (ii) organizational (meso) level. At the project level, relevant QM data can be exchanged between stakeholders (Figure 1). This will enable the client to check contractor's compliance on a random or regular basis, in a way that is similar to many of the manual auditing procedures currently in operation. Likewise, the contractor may check the relevant quality data of the client and consultants, such as progress of payment, status on issuance of instructions, etc. Not only should this improve the transparency of the whole QM process at the project level but also, as quality records are kept in a systematic manner, the causes and timing of defects or problems should be easily traceable by any stakeholders.

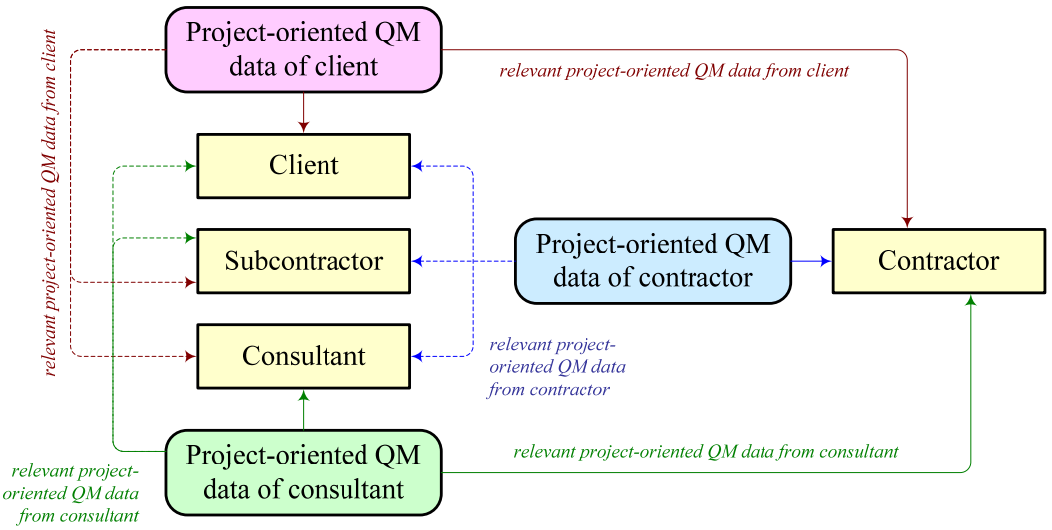

Figure 1. Exchanging project-based QM data amongst stakeholders.

At the organizational level, the e-Quality system should provide essential information to the certification bodies, independent technical audit, client's QM team, internal audit, etc. (Figure 2). Information related to all relevant projects performed by the organization would be summarized. The system allows the certification bodies to check the conformity of an organization on-line and perform random or spot checks at any time.

This helps prevent organizations from cheating by completing the QM forms at time of auditing.

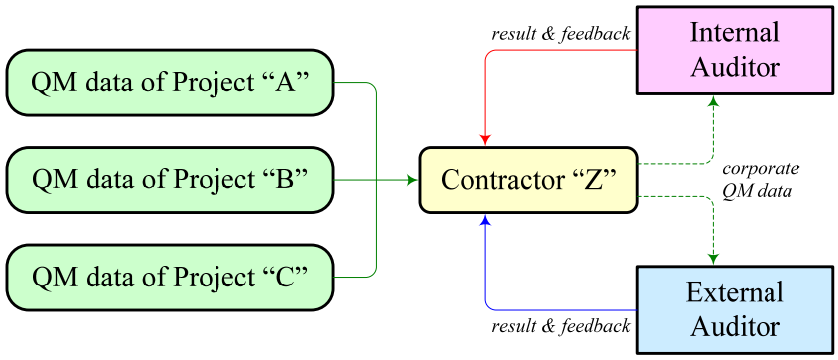

Figure 2. Organizational QM data for auditing purpose.

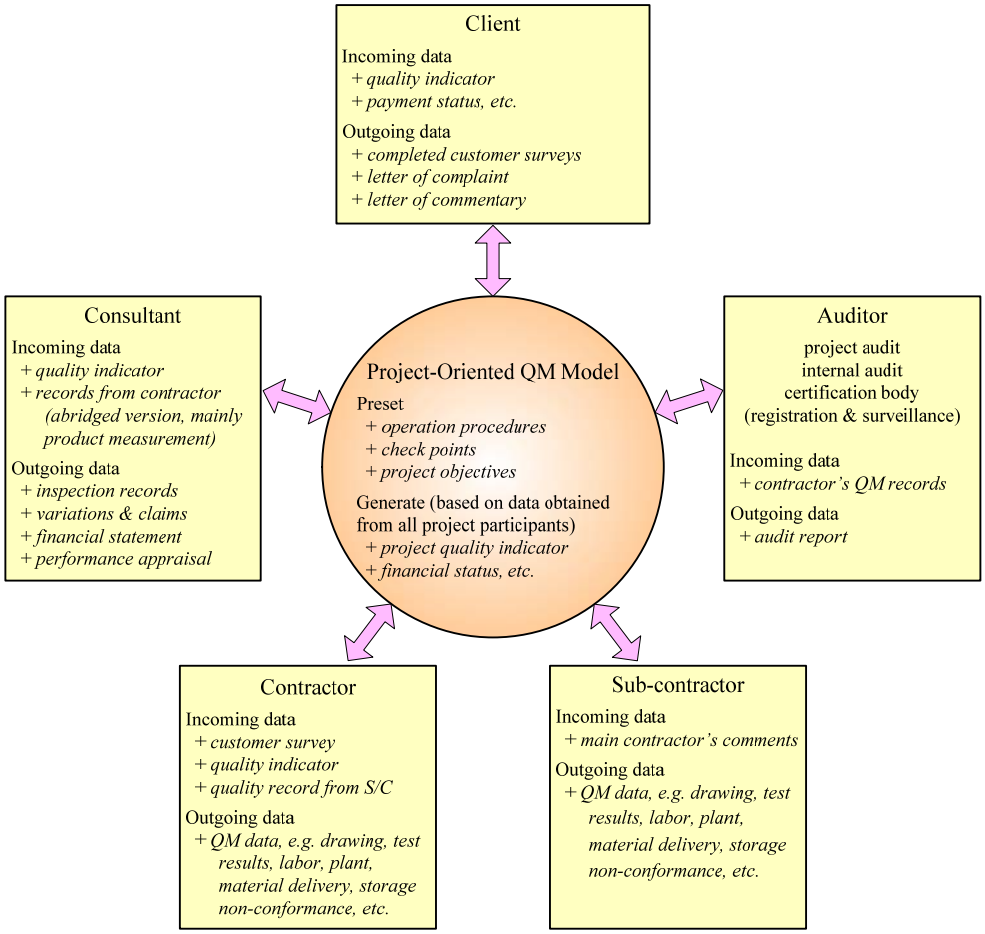

Figure 3. The flow of project-oriented QM data.

Figure 3 outlines the data flows amongst the client, consultant, contractor, sub-contractor, auditor, etc. Being the one who is responsible for construction, the contractor and subcontractors are required to submit QM data pertinent to the project, such as material delivery and storage, non-conformance, test results, etc. These QM records are made available to the client, internal auditor and consultant for checking and monitoring. In contrast, information lodged by the consultants includes inspection reports, payment status and performance appraisal, while the client would have to complete the customer surveys and to present the letters of complaint or commentary to the IPQM system. Such feedbacks will be made available to the contractor and subcontractors to facilitate continual improvements.

Integrative Project-Oriented QM Framework

Interviews were conducted with domain experts to determine the most suitable conceptual framework to represent the proposed IPQM model, and the basic framework consists of five components: (i) data entry, (ii) data verification, (iii) assessment, (iv) security, and (v) reporting.

Data entry allows (a) registered users like clients, consultants, contractors, subcontractors and supplies to post their QM documentations; (b) registered users to submit the project-specific QM data; (c) certifying or accreditation bodies to enter the assessment criteria and requirements through the web-based interface, and (d) organizations to register as approved users of the system.

Data verification aims to ensure the validity of data obtained. A potential problem of any Internet-based systems is that data may be submitted from any source, and there is a danger that the data may be invalid. Therefore, any raw data obtained shall be vetted by independent quality auditors or a review panel acceptable to the industry.

Assessment evaluates whether or not (i) a new QM system should be accredited and (ii) whether or not an organization has complied with the requirements of the ISO standard and those as stated in the quality manual of the organization. Since organizations may experience difficulties in establishing a baseline to determine success or to compare with last year's performance (Krizan, 1999), a suitable assessment model pertinent to the construction QM system is needed.

Security aims to ensure that sensitive organizational information will not be divulged to unregistered or irrelevant users of the system. The Internet-based system must have stringent security measures to prevent hackers from accessing sensitive information. This module determines what information to be made available to which entities within the system through various security measures.

Reporting provides the required information to users via the web-based interface. Information pertinent to the project level includes the status of payment and instruction, etc. As is well known, effective QM is not only focused on the production process but also focused on the customer-oriented process such as operation. The customer-oriented process relates to post construction QM such as feedback and fault/defects control and treatment (including the take-over report to reflect the initial operation status for starting the post construction journey) and fault/defects report or unsatisfied report (UR) to reflect abnormal conditions for asking support and service which is normally needed through support and analysis from external experts. These activities could be effectively executed

by the Internet/ Extranet to save time and remedy faults, trace problems and track the treating process to succeed the support and service. Normally, a team of experts should independently execute the fault/problem/trouble shooting process. The Internet tool can therefore also help produce and manage the post construction quality management periodical report along with the production quality auditing records to finish a historical record throughout the life cycle of the project.

Prototype Model

The current prototype of IPQM was developed using a bundle of software and programming languages including DreamWeaver™; Fireworks™; Flash™; MySQL™ (Linux™ version); Hypertext Markup Language (HTML); Hypertext Preprocessor (PHP); and Standard Query Language (SQL).

Figure 4 shows the homepage of the e-Quality model. Before using the model to record or retrieve QM data, all relevant project participants are required to register with the system. Various types of companies and users will be allotted different access levels and authorities. For instance, the client will be allowed access to most of the project-oriented QM data recorded by the contractor and consultants, and this would allow the client to keep monitor the performance of the project participants as well as the project itself. In contrast, subcontractors would only be able to retrieve some related information (e.g. the inventory and storage of material) from the main contractor.

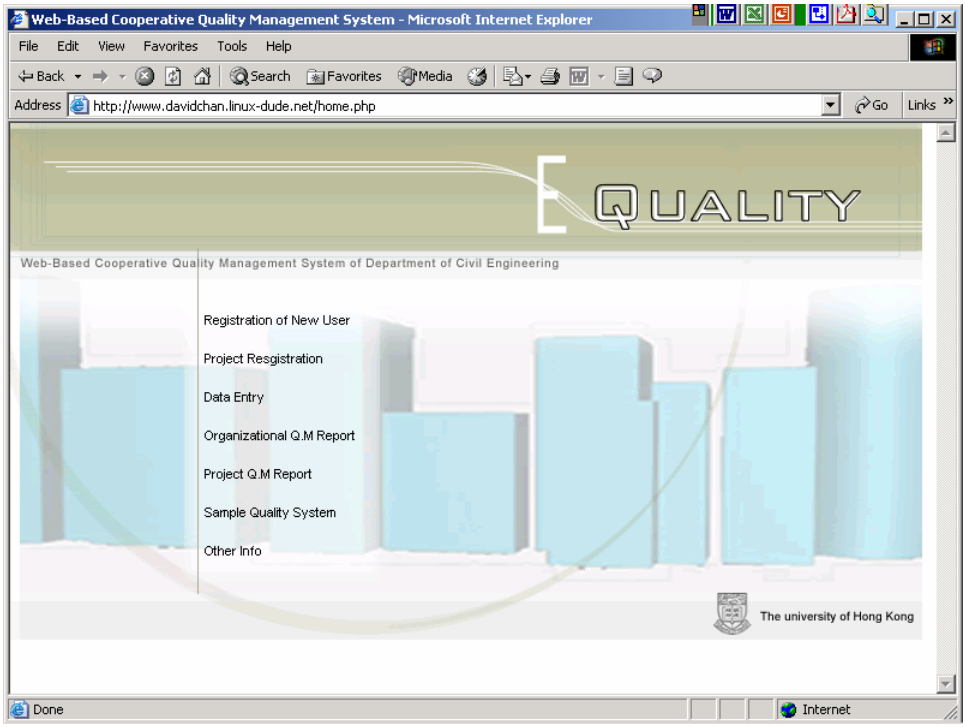

Figure 4. Figure caption.

Project registration not only captures crucial project particulars, such as the project type, estimated and actual project sum and duration, liquidated damages, procurement method, etc., but also records the organizations and key personnel involved. Having defined the contracting parties allows the system to determine who should be granted access to manipulate the QM data pertinent to that particular project. The project details would, on one hand serve as a general information library, while on the other hand facilitate decision support when combined with the QM information.

The entry of QM data is then done by each organization involved in the project. Standardized QM forms are available in the e-Quality model to improve consistency. Users can selected the appropriated forms indexed according to the four different stages of the project life cycle namely design, tender, construction and operation. The completed forms can be submitted to the IPQM system online. The QM data will then reside in the server-based database management system – MySQL™.

Illustrative example

Take the example of a resident engineer who has uncovered a defective structural component during the construction stage. The first action he/she would do is to complete a non-conformance form to formally record the details of nonconformity, location, date of discovery, etc. Upon receiving the engineer's notification, the contractor would then arrange a joint inspection with the resident engineer, and a corresponding form would be completed by the contractor's representative to outline their observations, agreed remedial measures (e.g. to take down and rebuild or repair) and the responsible parties (in terms of time and/or cost consequence). Should the substandard works be related to a subcontractor, similar arrangement would be made and relevant details (e.g. the detailed repair method) would be recorded by the subcontractor as a QM measure.

Figure 5. Project-related non-conformance report.

In the above scenario, the QM records kept by the consultant, contractor and subcontractor can be extracted and summarized into useful reports (e.g. Figure 5). The report might be useful to the client and consultants as the method used for rectifying the defects could affect the subsequent works, inspection or even testing. More important, as the crucial dates including the notification, inspection and repair dates are recorded in a systematic manner; it is easier for project participants to establish the liability in case delay occurs. This can eliminate any unnecessary claims and disputes due to a lack of information or records. Based on the reports (e.g. the nonconformance reports) generated by the IPQM system, the client can determine whether the problems are promptly and satisfactorily addressed by the relevant parties. The client can also make use of the reports to establish the fault/problem patterns. These not only facilitate the client to express vendors' performance more objectively, but they can also explicitly pinpoint their dissatisfaction (e.g. in the quality of work, promptness of repair, etc.) to the vendors in order to realize the true spirit of customer satisfaction and continual improvements.

Conclusion

In the past, the practice of QM in construction projects has been almost exclusively concerned with preserving corporate QM records so as to demonstrate due observance of the required QM procedures. Hence, there has been insufficient dissemination of project-based QM information amongst parties involved in the supply chain for mutual monitoring and remedial re-alignment. As a result, customer satisfaction and continual improvement has not been sustained.

The IPQM model proposed in this paper aims to facilitate the distribution of relevant QM records to other project participants through the Internet. The increased dissemination of useful project-oriented QM data is this way not only would help project team members to manage and supervise a construction project, but could also be used as an administrative tool to enhance the day-to-day operations and/or provide formal records in case contractual claims and disputes arise. This should provide an improvement in the overall product/service standard of all project team members as well as the quality of construction project.

A conceptual framework comprising five components namely (i) data entry, (ii) data verification, (iii) assessment, (iv) security, and (v) reporting is reported. Based on the conceptual framework, a prototype IPQM model is presented using the Internet technologies. The prototype allows QM records to be input by registered users, and relevant project-oriented QM information is extracted by the model for decision support.

The work described here offers clear evidence of the potential for the use of Internet technologies in developing an implementable IPQM system, and suggests that an even more comprehensive system might be attainable. Also, bearing in mind that extranet is becoming increasingly popular in both manufacturing (Anandarajan *et al*, 1998; Tang and Lu, 2002) and construction (Bender and Septelka, 2002; Alshawi and Ingirige, 2003) industries, a clear opportunity exists for migrating the system to an extranet environment (i.e. to a bridge between the public Internet and the private corporate intranets). Both these development appear to be worthy of further research.

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